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(54) Title: ARRANGEMENT FOR ELECTROTHERMAL TREATMENT OF THE HUMAN OR ANIMAL BODY

(57) Abstract

An arrangement (1) for electrothermal treatment of the human or animal body, in particular for tissue coagulation or electrotomy, comprising two electrodes (3, 4) for insertion into the body to be treated, wherein to produce an electrical or electromagnetic field heating the body tissue in the therapy area the two electrodes (3, 4) are electrically insulated from each other and are at a spacing from each other and are each connected by way of a respective feed line to an extracorporally arranged current source, wherein an elongate catheter (2) is provided for joint insertion of the two electrodes (3, 4) into the body, wherein the two electrodes (3, 4) are arranged displaced relative to each other in the axial direction of the catheter (2) and are connected to the catheter (2) or are a component of the catheter (2).

Arrangement for electrothermal treatment of the human or animal body

Description

The invention concerns an arrangement for electrothermal treatment of the human or animal body, in particular for electrocoagulation or electrotomy, as set forth in the classifying portion of claim 1.

It has long been known in surgery to use for the purposes of tissue coagulation and tissue division high-frequency alternating currents in the frequency range of between 300 kHz and 2 MHz, whereby the tissue being treated is coagulated or vaporized, this being referred to electrocoagulation or electrotomy. In this case a distinction is to be drawn between monopolar and bipolar HF-thermotherapy.

In monopolar HF-thermotherapy an electrode - also referred to as the neutral electrode - is designed in the form of a patient delivery line of large area and is fixed to the patient in the proximity of the point of intervention. The actual working electrode - also referred to as the active electrode - is adapted in terms of its shape to the respective use involved. Thus, large-area ball, plate or needle electrodes are used for tissue coagulation while thin lancet or loop electrodes are used in tissue division.

In the case of bipolar HF-thermotherapy in contrast, both electrodes are arranged in the immediate proximity of the intervention location so that the action of the alternating current is limited to the immediate

surroundings of the intervention location, thereby affording a high level of safety for patient and user as accidents due to capacitive leakage currents or burning at the neutral electrode can no longer occur. A further advantage of bipolar HF-thermotherapy lies in the substantially lower level of load resistance of the tissue between the two electrodes, which makes it possible to reduce the generator output required while maintaining the thermal effect.

HF-thermotherapy can also be divided up according to the position of the electrodes into surface coagulation on the one hand and depth coagulation on the other hand.

Surface coagulation using the bipolar technique involves employing two probe electrodes which are arranged parallel and which are applied to the surface of the tissue whereby where the subjacent tissue is heated as a result of the flow of current and thereby coagulated.

In regard to depth coagulation, for monopolar electrotomy it is known to use needle, lancet or loop electrodes. In that case electric arcs must be generated at the active electrode in order to vaporize the tissue in front of the active electrode and thus to effect a cut in the tissue. That is comparatively simple in the monopolar procedure as here only a given field strength is required in order to trigger off spark flashover at the active electrode. The bipolar procedure puts here relatively high demands on the design of the electrode configuration as the physical phenomena involved in this respect are not easy to manage. Therefore only a few bipolar electrode arrangements for depth coagulation are known, thus for example the bipolar needle electrode which inter alia is suitable for myomatherapy. This previously known bipolar electrode arrangement comprises two needle electrodes which are arranged in parallel and which are caused to pierce into the tissue whereby the tissue between the electrodes is heated as a result of the flow of current and thereby coagulated.

A disadvantage with the known bipolar electrode arrangements for depth coagulation however is the relatively complicated operation of placing the electrodes through two piercing locations. In addition the field distribution can be only relatively inaccurately predetermined by the user so that the relative position of the two electrodes with respect to each other cannot generally be exactly predetermined.

It is further known from DE 43 22 955 A1 for the coagulation of body tissue to use laser radiation which can be transmitted into the therapy area by way of a cylindrical light waveguide, wherein the previously known light waveguide in addition also permits the transmission of ultrasonic energy so that the two therapy procedures of ultrasonic tissue division and laser coagulation can be combined.

DE 44 32 666 A1 also discloses a waveguide which, besides the transmission of ultrasonic waves and laser transmission, also permits the transmission of high frequency energy so that the processes referred to in the opening part of this specification for high frequency surgery can also be used at the same time for laser and ultrasonic surgery. In that respect the previously known waveguide is cylindrical and for the transmission of high frequency energy has two also cylindrical layers of electrically conductive material which are electrically insulated from each other. The previously known waveguide therefore admittedly permits the transfer of high frequency energy from an extracorporally arranged high frequency generator into the therapy area, but it does not permit the high frequency energy to be given off to the body tissue.

The object of the present invention is therefore that of providing an arrangement for electrothermal treatment of the human or animal body, which by means of a bipolar electrode arrangement permits interstitial tissue coagulation and which avoids the above-indicated disadvantage of the known arrangements of this kind.

Taking an arrangement as set forth in the classifying portion of claim 1 as its basic starting point, that object is attained by the features recited in the characterizing portion of claim 1.

The invention includes the technical teaching of using for thermotherapy purposes a bipolar electrode arrangement in which the two electrodes are arranged in succession on an elongate catheter in order to permit joint insertion of the two electrodes into the body through a single penetration point, wherein the two electrodes are connected to the catheter or are a component of the catheter.

In this respect and hereinafter the term catheter is to be interpreted broadly and is not limited to the hollow-cylindrical arrangements which are preferably used and which are described in detail hereinafter, but can also be carried into effect with solid arrangements of virtually any cross-sections. The only crucial consideration for the mode of operation according to the invention is that the two electrodes are jointly inserted into the body of the patient through one penetration point.

The catheter according to the invention now makes it possible for the first time for the electrodes to be placed in deep layers of tissue and there to achieve a partial tissue coagulation effect.

The electrodes are connected to a current source in the arrangement according to the invention for the supply of the electrical energy required for heating the tissue, wherein the term current source is not limited to current sources in the narrower sense with a constant current, but also includes the alternating current generators which are preferably used, in particular high frequency generators.

In an advantageous alternative embodiment of the invention the axial spacing between the two electrodes is adjustable in order to be able to vary the field distribution. If the insulator length between the two electrodes in the axial direction is for example less than twice the electrode diameter, it is advantageously possible to achieve spherical

coagulation necroses, whereas the shape of the coagulation necroses with greater insulator lengths is rather oval.

Therefore the preferred embodiment of this variant provides that the proximal electrode is of a hollow nature, at least at its distal end, in order to be able to receive the distal electrode in its interior. In order in this respect to permit axial displaceability of the distal electrode in the proximal electrode, the external cross-section of the distal electrode is smaller than the internal cross-section of the proximal electrode. It is important in this respect for the two electrodes to be suitably electrically insulated from each other as the two electrodes can overlap in the axial direction. For that purpose, provided on the inside of the proximal electrode or on the outside of the distal electrode is an electrical insulation which for example - as in above-mentioned DE 44 32 666 A1 - can comprise a dielectric coating or a sheath of insulating material, which preferably comprises PTFE or polyimide, wherein the cross-section of the insulating material sheath is preferably so adapted to the cross-section of the distal or proximal electrode that the insulating material sheath forms a press fit with the proximal or distal electrode respectively and is thus fixed on the electrode. The two electrodes are therefore arranged coaxially and are displaceable in the axial direction relative to each other in order to be able to alter the field distribution, wherein the distal electrode is received over a part of its longitudinal extent by the proximal electrode.

In this variant of the invention, as also in the other variants of the invention, the cross-section of the two electrodes is preferably cylindrical, wherein the inside diameter of the proximal electrode in this variant must be greater than the outside diameter of the distal electrode so that the distal electrode is displaceable in the axial direction. The invention however is not restricted to cylindrical electrode shapes but can also be carried into effect with other electrode cross-sections. The only crucial consideration for the function according to the invention in this variant thereof is that the internal cross-section of the proximal electrode is so

adapted to the external cross-section of the proximal electrode that the distal electrode can be displaced in the proximal electrode in the axial direction in order to be able to vary the axial spacing between the two electrodes.

In another variant of the invention adjustment of the axial spacing between the two electrodes is made possible by an elongate carrier element of electrically insulating material, which is arranged displaceably in the proximal electrode and which at its distal region laterally has the distal electrode. At least at its distal end therefore the proximal electrode is hollow in order to be able to receive the carrier element. In this case the internal cross-section of the proximal electrode is so adapted to the external cross-section of the carrier element that the carrier element is displaceable in the axial direction in order to be able to adjust the axial spacing between the distal end of the proximal electrode and the distal electrode which is arranged on the carrier element. In this variant of the invention the distal electrode is mounted laterally to the electrically insulating carrier element and can for example comprise an annular metal coating or a metal cover or sleeve which for assembly purposes is pushed axially onto the carrier element and forms a press fit therewith.

In accordance with another variant of the invention the spacing of the two electrodes in contrast is predetermined in order to afford a simple catheter structure and to ensure a predetermined field distribution. For that purpose the catheter also has an elongate carrier element of electrically insulating material, at the side of which the electrodes are fixed in the axial direction and arranged in spaced relationship. In that arrangement the carrier element serves on the one hand for mechanical fixing of the electrode in order to achieve a predetermined field distribution by virtue of the constant electrode spacing. On the other hand the function of the carrier element is to electrically insulate the two electrodes from each other, and for that reason it comprises electrically insulating material. In the preferred embodiment of this variant the

carrier element is of a cylindrical cross-section, the two electrodes being hollow-cylindrical and being arranged to extend around the longitudinal axis of the carrier element. For that purpose the electrodes can be for example applied in the form of a metal coating to the surface of the carrier electrode or each can comprise a metal cover or sleeve which is pushed onto the carrier element and forms therewith a press fit.

In another embodiment of this variant axial fixing of the electrodes is not implemented by the arrangement thereof on a carrier element, but by a respective connecting element between the electrodes, which connects the electrodes together at their ends. Besides axially fixing the electrodes, the function of the connecting element is also to insulate the two electrodes from each other, and for that reason it comprises an electrically insulating material. In this case the electrodes and the connecting portions are preferably cylindrical and are of the same cross-section so that the external contour of the catheter at the transitions between the electrodes and the connecting elements is of a steady configuration without projecting edges, which is important in terms of introducing the catheter into the body of the patient in order to avoid unnecessary injury.

In accordance with a development of the invention there are provided more than two electrodes which are arranged at a mutual spacing in the axial direction of the catheter. As already described above, by way of example the electrodes can be mounted laterally to an elongate carrier element or - as already described above - they can each be separated from each other by a connecting element of electrically insulating material.

In the preferred embodiment of this variant the individual electrode pairs which are arranged in an axially distributed array along the longitudinal axis of the catheter are actuated separately and for that purpose each have respective separate feed lines which are preferably passed out of the body through a hollow passage in the interior of the

catheter and can be connected to a suitable control unit which permits individual adjustment for example of current, voltage and/or frequency. In that way by virtue of the superimposition of the fields produced by the individual pairs of electrodes it is possible for the field distribution to be freely predetermined within wide limits in order for example in an electrocoagulation procedure to destroy as little healthy tissue as possible. In an advantageous development of this variant the extracorporal control device has a plurality of storage elements in which the electrical parameters such as current, voltage and frequency for various field distributions are stored so that the user only has to decide on the desired field distribution, whereupon the control device then reads out of the respective storage element the electrical parameters required to achieve that field distribution and correspondingly actuates the individual pairs of electrodes.

Other advantageous developments of the invention are characterized in the appendant claims or are described in greater detail hereinafter together with the description of the preferred embodiment of the invention with reference to the drawings in which:

Figure 1 as a preferred embodiment of the invention shows an arrangement for the electrothermal treatment with a catheter for insertion of the electrodes into the body and a handling portion for guiding the catheter,

Figures 2a and 2b show the catheter of the arrangement of Figure 1 with retracted and extended core electrode respectively,

Figures 3a and 3b show various catheters with fixed electrodes for achieving a predetermined field distribution,

Figure 4 shows a catheter with five electrodes for permitting particular forms of field distribution,

Figure 5 shows a flexible catheter for use in minimal-invasive surgery,

Figures 6a, 6b and 6c shows various catheters which permit a feed of rinsing fluid, and

Figure 7 shows a further catheter with an adjustable electrode spacing.

Figure 1 shows as a preferred embodiment of the invention an arrangement 1 for electrothermal treatment of the human or animal body, which essentially comprises a catheter 2 with a core electrode 3 and a sheath electrode 4, together with a handling portion 5 for guiding the catheter 2, with the catheter 2 being shown in detail in Figures 2a and 2b.

The catheter 2 permits adjustment of the axial spacing between the two electrodes 3, 4 in order to be able to predetermine the field distribution in the therapy area. For that purpose the catheter 2 has the cylindrical core electrode 3 of high-quality steel, of a diameter of 800 μm, which is provided at its peripheral surface as far as its distal end with a 50 μm thick polyimide layer 6 for electrical insulation purposes. That coated core electrode 3 is disposed coaxially displaceably in the hollow-cylindrical sheath electrode 4 which also comprises high-quality steel and is of an inside diameter of 900 μm. The outside diameter of the sheath electrode 4 is 1500 μm with a length of 10 cm.

Before the catheter 2 is inserted into the tissue the inner core electrode 3 can be retracted by a displacement mechanism integrated into the handling portion 5, so that the core electrode 3 and the sheath electrode 4 together form a symmetrically ground insertion puncture bar, as is shown in Figure 2a.

After the catheter 2 has been inserted into the tissue, the core electrode 3 can then be extended in the axial direction and thus forms with the insulating polyimide layer 6 and the sheath electrode 4 a dipole configuration, as shown in Figure 2b. In addition axial displacement of the core electrode 3 also permits adjustment of the axial spacing between the two electrodes 3, 4 and can thus provide for specific and directed influencing of the field distribution in the therapy area. Actuation of the

displacement mechanism for the core electrode 3 is effected by a push-button rocker 7 which is integrated into the handling portion 5 which is in the shape of a pistol grip, for ergonomic reasons. In addition the handling portion 5 contains a switch 8 with which the electrode arrangement can be connected to an HF-generator which is connected to the handling portion 5 by way of an electrical feed line 9. The handling portion 5 also has an unlocking mechanism 10 by way of which the core electrode 3 can be released and then pulled axially out of the sheath electrode 4. After unlocking of a closure mechanism 11 the sheath electrode 4 can then also be pulled out axially. Separation of the electrodes 3, 4 from the handling portion 5 permits sterilization and subsequent re-use of the electrodes 3, 4 in a simple fashion.

The catheter 2 comprising the core and sheath electrodes 3, 4 is connected to the handling portion 5 by way of a rotatable support mounting 12 and by virtue of its angled shape permits operation which is adapted to the field of vision of the doctor, as is necessary for example in the case of nose concha coagulation.

In addition the illustrated arrangement 1 permits the introduction of a rinsing or flushing fluid into the tissue in the therapy area in order to improve electrical coupling. In that way it is possible to compensate for the fluid loss which occurs during coagulation and which otherwise results in a change in the electrical impedance of the tissue in the therapy area and adversely affects electrical coupling. The handling portion 5 therefore ascertains from the applied voltage and the current across the electrodes 3, 4 the tissue impedance and delivers a suitable amount of rinsing fluid to the tissue in order to maintain the tissue impedance constant. The rinsing fluid is fed to the handling portion 5 by way of a hoze 13 from a separate rinsing pump and is pumped through the hollow sheath electrode 4 into the therapy area. There the rinsing fluid then issues through a gap between the core electrode 3 and the sheath electrode 4 into the tissue.

Figures 3a,3b each show a catheter 14 and 15 respectively, with a proximal electrode 17, 18 and a distal electrode 16, 18, wherein the spacing between the two electrodes 16, 17 and 18, 19 respectively is constant in order to achieve a predetermined field distribution and to permit the catheter 14, 15 to be of a simple structure. In this case the two electrodes 16, 17 and 18, 19 respectively are of a cylindrical configuration and at their end faces are mechanically connected together by an also cylindrical connecting element 20 and 21 respectively of electrically insulating material, wherein the connecting element 20, 21, like also the proximal electrode 17 and 19 respectively, has an axially extending hollow passage for receiving the electrode feed line. In the case of the catheter 14 shown in Figure 3a the external cross-sections of the two electrodes 16, 17 and the cross-section of the connecting element 20 are the same so that the external contour of the catheter 14 is smooth, even at the transitional locations between the electrodes 16, 17 and the connecting element 20, thereby facilitating insertion of the catheter 14 into the body of the patient. In the case of the catheter 15 shown in Figure 3b the proximal electrode 19 in contrast is of a larger cross-section than the distal electrode 18 and the connecting element 21, while the proximal electrode 19 tapers conically to the cross-section of the connecting element 21, at the transition to the connecting element 21.

Figure 4 further shows a catheter 22 which differs from the above-described catheters essentially by virtue of the greater number of electrodes 23.1 through 23.5 which are arranged along the longitudinal axis of the catheter 22 and which substantially comprise annular metal coatings which are applied to the peripheral surface of a cylindrical carrier element 24 of electrically insulating material. Contacting of the electrodes 23.1 through 23.5 is individually effected in each case by means of feed lines which are laid in an axially extending handling portion in the carrier element. On the one hand the partial current density at the electrodes 23.1 through 23.5 can be reduced by virtue of the larger number of

electrodes 23.1 through 23.5, thereby preventing an excessive rise in temperature. On the other hand, by virtue of superimposition of the individual fields, it is possible to generate a different field distribution from an arrangement involving only two electrodes. In addition there is the possibility of specifically influencing the field distribution by switching individual pairs of electrodes on and off.

Figure 5 shows as a further embodiment of the invention a catheter 25 which is flexible and thus permits insertion even into body cavities with curved entry passages, which is important in particular in the case of minimal-invasive medicine (MIM). The catheter 25 essentially comprises a cylindrical core electrode 26 of spring steel wire which is surrounded by a hollow-cylindrical sheath electrode 27 formed from a flexible metal mesh. Except for its distal end, the core electrode 26 is provided at its peripheral surface with an electrically insulating coating 28 in order to insulate the two electrodes 26, 27 from each other.

Figures 6a, 6b and 6c shows further advantageous embodiments of catheters 29, 30, 31 each with a hollow-cylindrical proximal sheath electrode 32, 33, 34 and a distal core electrode 36, 37, 38 of a cylindrical configuration. The illustrated catheters 29, 30, 31 advantageously permit a feed of rinsing fluid into the tissue in order to compensate for the fluid loss of the tissue during the coagulation procedure and to prevent a worsening, that this entails, in the electrical coupling effect. In this case the feed of the rinsing fluid is implemented through an axially extending hollow passage in the proximal sheath electrode 32, 33, 34 and is guaranteed by an extracorporally arranged rinsing agent pump. With the illustrated catheters 29, 30, 31 on the other hand the discharge of rinsing fluid in the therapy area is effected in a different manner. Thus the catheter 29 shown in Figure 6a has in the peripheral surface of the sheath electrode 32 a plurality of distally arranged apertures 35 through which the rinsing fluid can issue from the hollow passage into the tissue. In the catheter 30 shown in Figure 6b in contrast the rinsing fluid issues through

a gap between the sheath electrode 33 and the core electrode 36 into the tissue. Instead of this the catheter 31 shown in Figure 6c has a hollow passage which is continuous in the axial direction and which also passes through the core electrode 37 and which opens in the distal end of the core electrode 37 so that the rinsing fluid issues into the tissue at the distal end surface of the distal electrode 37.

The rinsing fluid used is preferably physiological saline solution which provides for good electrical coupling to the tissue and which reduces the risk of tissue carbonization by virtue of limiting the temperature to <100°C. In this case insulation of the two electrodes 32, 38 and 36, 33 and 34, 37 respectively relative to each other is also effected by a coating 39, 40, 41 of electrically insulating material, which is applied to the core electrode 36, 37, 38.

Instead of the feed of rinsing fluid the hollow passage of the catheter 31 shown in Figure 6c may also accommodate a optical waveguide for a modified optical biopsy, which by way of a measurement of the backscatter signal or tissue fluorescence upon irradiation permits precise positioning of the catheter 31 in the therapy area. In addition laser transmission through an integrated optical waveguide in dependence on the wavelength used also affords the possibility of measuring the flow of blood by Doppler measurement. Furthermore, the laser radiation which is transmitted into the therapy area by way of an optical waveguide of that kind can also be used for thermo-optical tissue coagulation. Finally there is also the possibility of positioning a temperature sensor for coagulation control, through the hollow passage.

Finally, Figure 7 shows a further catheter 42 which permits adjustment of the electrode spacing in order to be able to influence the field distribution in the therapy area. For that purpose the illustrated catheter 42 has a cylindrical carrier element 43 of electrically insulating material, at the distal end of which a distal electrode 44 is applied laterally in the form of an annular metal coating.

This carrier element 43 is guided by a proximal electrode 45 of a hollow-cylindrical configuration, wherein the outside diameter of the carrier element 43 is less than the inside diameter of the proximal electrode 45 so that the carrier element 43 with the distal electrode 44 is displaceable in the axial direction in order to be able to adjust the electrode spacing. At its distal end the carrier element 43 is ground in the form of a puncture bar in order to make it easier to insert the catheter 42 into the body of the patient.

The invention is not limited in its implementation to the preferred embodiments described hereinbefore. On the contrary it is possible to envisage a number of alternative configurations which make use of the illustrated principles, even in constructions of a fundamentally different kind.

CLAIMS

1. An arrangement (1) for electrothermal treatment of the human or animal body, in particular for tissue coagulation or electrotomy, comprising two electrodes (3, 4) for insertion into the body to be treated, wherein to produce an electrical or electromagnetic field for heating the body tissue in the treatment area the two electrodes (3, 4) are electrically insulated from each other and arranged at a spacing from each other and are connected by way of a respective feed line to an extracorporally arranged current source characterized in that an elongate catheter (2) is provided for joint insertion of the two electrodes (3, 4) into the body, wherein the two electrodes (3, 4) are arranged in mutually displaced relationship in the axial direction of the catheter (2) and are connected to the catheter (2) or are a component of the catheter (2).

2. An arrangement as set forth in claim 1 characterized in that the proximal electrode (4) for receiving the distal electrode (3) is hollow at least on a distally disposed part of its longitudinal extent, wherein the external cross-section of the distal electrode (3) is so adapted to the internal cross-section of the proximal electrode (4) that the two electrodes (3, 4) are axially displaceable relative to each other to alter the axial electrode spacing and thus the field distribution, and that for electrical insulation of the two electrodes (3, 4) relative to each other provided on the inside of the proximal electrode (4) and/or on the outside of the distal electrode (3) is an electrical insulation (6) which extends therearound with respect to the longitudinal axis thereof.

3. An arrangement as set forth in claim 2 characterized in that the distal electrode (3) is of a cylindrical external cross-section and the proximal electrode (4) is of a hollow-cylindrical configuration for receiving the distal electrode (3).

4. An arrangement as set forth in claim 1 characterized in that the catheter (22) has an elongate carrier element (24) of electrically insulating material, wherein the two electrodes (23.1, 23.2, 23.3, 23.4) are mounted laterally to the carrier element (24) and are fixed to produce a predetermined field distribution in the axial direction.

5. An arrangement as set forth in claim 1 characterized in that the catheter (42) has an elongate carrier element (43) of electrically insulating material, wherein the distal electrode (44) is mounted laterally to the carrier element (43), that the proximal electrode (45) for receiving the carrier element (43) is hollow at least over a distally disposed part of its longitudinal extent and is of an internal cross-section which is so adapted to the external cross-section of the carrier element (43) that the carrier element (43) with the distal electrode (44) and the proximal electrode (45) are displaceable axially relative to each other to alter the axial electrode spacing and therewith the field distribution.

6. An arrangement as set forth in claim 4 or claim 5 characterized in that the carrier element (24, 43) is of a cylindrical external cross-section and at least one electrode (23.1, 23.2, 23.3, 23.4, 44, 45) is of a hollow-cylindrical configuration and is arranged coaxially with respect to the carrier element (24, 43).

7. An arrangement as set forth in claim 1 characterized in that for mechanically connecting the two electrodes (16, 17, 18, 19) together the catheter (14, 15) has a connecting portion (20, 21) of electrically insulating material, which is arranged between the two electrodes (16, 17, 18, 19) and which connects them together at their ends.

8. An arrangement as set forth in one of the preceding claims characterized in that the proximal electrode (32, 33, 34) and/or the distal electrode (37) has a hollow passage extending along its longitudinal axis for the feed of a rinsing fluid into the therapy area and/or for placing a temperature sensor or an optical waveguide.

9. An arrangement as set forth in claim 8 characterized in that for delivery of the rinsing fluid in the therapy area at least one aperture (35) is provided in the wall of the proximal electrode (32) and/or the distal electrode and/or a gap is provided between the proximal electrode (33) and the distal electrode (37) at least at the distal end of the proximal electrode (33).

10. An arrangement as set forth in one of the preceding claims characterized in that the distal electrode (3, 16, 18, 26, 36, 37, 38) or the carrier element (24, 43) has a point which tapers towards its distal end to facilitate insertion into the body.

11. An arrangement as set forth in one of the preceding claims characterized in that the distal electrode substantially comprises an electrically conductive coating on the peripheral surface of an optical waveguide.